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(54) Anaesthetic system.

(57) An anaesthetic system (10) comprises an inspiratory tube (12) and an expiratory tube (14) which runs along the tube (12). The tube (14) terminates at an outlet (30) controlled by a relief valve (16). A secondary outlet (26) in the tube (14) is controlled by a valve (18). One end of the tube (12) may be attached to a face mask (24) while a reservoir bag (22) is connected to an opposite end. The anaesthetic system of the invention will find application in the different systems presently in use.

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ANAESTHETIC SYSTEM

This invention relates to anaesthetic apparatus and in particular, to anaesthetic breathing systems.

5

The term "anaesthetic system" or anaesthetic breathing system, when used in this specification, is taken to mean the connecting apparatus between the anaesthetic machine and the face mask or endotracheal tube which connects to a patient, except where the context indicates otherwise.

10

At present three systems which do not use recycling of anaesthetic gases through soda lime are widely in use, each finding application in one or two of the four circumstances in which inhalational agents are used. The Mapleson A or Magill system, is used for spontaneous respiration on adults and comprises a flexible tube delivering fresh gas from the machine, a reservoir bag at the machine end, and a pop-off valve, which is a simple relief valve, adjacent the patient's face. For controlled ventilation on adults, the Mapleson D or Bain system is used. This system comprises a fresh gas supply tube located within the bore of an expired gas removal tube. The outer tube is connected to the ventilator from where the expired gases may be removed from the theatre.

15

In paediatrics, a simple T-piece (Mapleson E) is generally used for both spontaneous respiration and controlled ventilation.

It is clear that each particular system is of limited application.

In addition, the Magill and the T-piece systems contribute to
5 the atmospheric pollution of the theatre by the introduction of expired respiration products and anaesthetic gas into the theatre, only the Bain system allowing easy scavenging.

A later system, based on the Mapleson A principle and developed by Lack, addressed the problem of theatre pollution by the
10 provision of a take-off tube for expired gases co-axially down the fresh gas supply tube. The take-off tube exits from the bore of the supply tube at a location remote from the patient where a relief valve is arranged to blow off when the expiration pressure of the patient overcomes the resistance of the valve mechanism.
15 The Lack system, can only be used in the same situations as the Magill.

Applicant is aware of the following United States Patents:

3,993,059 (Sjostrand) which relates to a high frequency positive ventilation system; 3,814,092 (Simionescu et al) which relates
20 to a portable anaesthetic machine; 4,007,736 (Schreiber) which

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describes a ventilator with a timing mechanism and 4,249,527
(KO et al) which relates to a pressure administrating apparatus
which maintains a positive pressure in the lungs of a patient
and United Kingdom Patents: 734,639 (Svenska Aktiebolaget Gras-
5 accumulator) which relates to a closed and open circuit anaesthetic
system and 1,272,583 (Please Medical Equipment) which describes
a ventilating machine designed to facilitate sterilization after use.
South African Patent 78/5078 (Miller) describes a co-axial anaesthetic
system which offers low resistance to gas flow.
It is an object of this invention to provide a system which will
find application in each and all of the circumstances mentioned
10 above and which will, moreover, be as efficient, or considerably
more efficient, than the systems presently in use in some or all
of the applications referred to.

It is further the object of this invention to facilitate the scavenging
of waste expired anaesthetic gases in all the applications mentioned
15 above, thus reducing theatre pollution and its consequent danger
to theatre staff to minimal levels or even eliminating pollution
completely.

Yet another object of this invention is to provide an anaesthetic
breathing system suitable for anaesthesia administration in both
20 the sophisticated academic environment and remote rural areas. By

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virtue of the properties of the apparatus the anaesthetist can
use very economical anaesthetic gas flows even without carbon
dioxide absorption and yet he does not prejudize the safety of
his patient. He can predict that carbon dioxide tension of his
5 patient during controlled ventilation even when the latter is
performed by hand. The invention is robust, simple and easily
sterilized and consequently has many advantages over the circle
absorber system which, unless specially adapted, is also
unsuitable for children.

10 Yet another object of this invention is to provide an apparatus
which is cheaper, easier to use, and less bulky than a
combination of currently used anaesthetic breathing systems
required for anaesthesia in the four circumstances mentioned
earlier. Further it eliminates the use of soda lime and thus
15 also the cost, transportation and the difficulties often
encountered in remote areas in obtaining it.

According to the invention there is provided an anaesthetic
system including a fresh gas supply tube, a reservoir bag
20 connected thereto through a valve, and an expiratory tube
/two outlets, one or both outlets being
having one or ~~both~~ ~~of an outlet~~ controlled by adjustable
means.

The arrangement of the invention permits a wide variety of applications for adult and child, spontaneous and controlled ventilation circumstances.

5 In one form of the invention the expiratory tube is provided with two outlets, a first outlet being controlled by a plug valve and downstream a second outlet upstream the first outlet being controlled by a relief valve which may be adjustable or a pop-off valve.

In another form of the invention expiratory tube has a single
10 outlet controlled by a screw-down type valve.

In both of these forms of the invention the port connecting the fresh gas supply tube to the reservoir bag may be controlled by a plug valve.

15 The fresh gas supply tube and the expiratory tube may be coaxial and the outlet is preferably located at a position remote from the patient from the patient end of the system.

Embodiments of the invention are shown in the accompanying drawings which are partly diagrammatical representations of an
20 anaesthetic system according to the invention.

The anaesthetic system 10 shown in Figure 1 comprises a fresh gas supply tube 12 or inspiratory tube, the patient end of which consists of flexible tubing, and an expired gas removal tube 14, or expiratory tube, which runs down the bore of the fresh gas supply tube 12 and exits therefrom at a location remote from the patient. The expired gas removal tube 14 terminates at the upper end thereof in a ^{/main} ~~secondary~~ outlet 30 controlled by a relief valve 16 which is a simple pop-off valve. A ^{/main} ~~secondary~~ outlet 26 ^{/upstream} ^{/main} ~~/downstream~~ of the ~~secondary~~ outlet 30 has a manually operable valve 18; and a second manually operable valve 20 is located in the fresh gas supply tube 12 to open or close a port 28 to a reservoir bag 22. Both valves 18, 20 are plug valves located within the tubes, with a central bore disposed co-axially with the principal axis of the tube, each arranged to close their outlets or port in one position of the levers 19, 21 and in the other position of the levers 19, 21 to open the outlet 26 or port 28. The pop-off valve 16 is a simple spring loaded valve with a screw cap which can be screwed in to close the valve 16.

A face mask 24 is shown attached to the patient end of the fresh gas supply tube 12. The expired gas removal tube 14 stops short of the end of the fresh gas supply tube and is supported therein by a set of radially extending vanes (not shown).

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In use the settings of the valves 16,18,20 will vary depending on the application of the system 10.

For adult spontaneous respiration the system 10 is used in a Mapleson A configuration. The reservoir bag port valve 20 is opened thereby including the reservoir bag 22 in the circuit and the outlet valve 18 is closed so that the relief valve 16 pops off during each expiration cycle of the patient. In this configuration the system can be regarded as a Lack system, fresh gas filling the reservoir bag 22 on the inspiratory limb and passing down the outer tube 12. Expired gases are vented by the inner tube 14 and exhausted through the pop-off valve 16 to be scavenged at the outlet 30.

The efficiency of the system 10 in this configuration has been determined on 20 anaesthetised patients using a fesh gas flow of 70 ml. kg^{-1} . min^{-1} .

During this test, the applicant found that the system 10, even with a fresh gas flow of only 50 ml. kg^{-1} . min^{-1} performed as efficiently as the Magill (Mapleson A system) with a fresh gas flow of 70 ml. kg^{-1} . min^{-1} .

To change the system 10 for controlled ventilation in both children and adults, the reservoir bag 22 is excluded from the circuit by means of the valve 20. A ventilator is connected to the outlet 26 while the outlet valve 18 is opened and the relief valve 16 is stopped down by screwing the cap down to the closed position. Fresh gas flows directly to the patient via the supply tube 12 and expired gas exits freely through the open outlet valve 18 to the ventilator.

The system functions as a modified Mapleson D system. Like the Bain (which is also modified Mapleson D system) normocarbia can be maintained with hyperventilation and a fresh gas flow of 10 $70 \text{ ml. kg}^{-1} \cdot \text{min}^{-1}$.

When used for either spontaneous or controlled ventilation in healthy adults, the system 10 maintains normocarbia with a fresh 15 gas flow of $70 \text{ ml. kg}^{-1} \cdot \text{min}^{-1}$ or less.

By including or excluding the reservoir bag 22, the system 10 can be quickly converted from a Mapleson D system to an A or vice versa.

For spontaneous respiration in paediatric anaesthesia, the system 10 may be used as a valveless Mapleson A, a system that, in the experience of the applicant, is two to three times more efficient than the traditional T-piece of Mapleson E system.

5

Fresh gas fills a smaller inspiratory reservoir bag 22 of 1 litre, in place of the adult 2 litre bag. Expired gases pass along the inner tube 14, but instead of being exhausted, as with adults, through the pop-off valve 16 which is fully closed, the outlet valve 18 is opened by the lever 19 to allow gas to escape freely without passing through the pop-off valve.

10

The system 10 required 3.1 times as little fresh gas as the T-piece to prevent rebreathing, an observation which was noted consistently during trials done by the applicant on children breathing spontaneously. It has been found that system 10 requires a maximum fresh gas flow of about $3.5 \text{ litres min}^{-1}$ for spontaneous respiration in children.

15

For controlled ventilation in children the system 10 is used as a Bain (modified Mapleson D) system as described above. A fresh gas flow of $3 \text{ litres min}^{-1}$ has been shown to maintain normocarbia or mild hypocarbia.

20

The resistance to expiration of the system 10 has been found to be remarkably low. It has a resistance of less than half that of 40 Magill systems tested, while for paediatric use it also offers some 50% less resistance than the T-piece.

5 In Figure 2 the system 10 of the Figure 1 is shown in an "inside out" configuration (100) in which the components function exactly as they do in the system 10 with the exception that the fresh gas now flows down the inner tube 112 while the outer tube 114 serves as the expiratory tube.

10 In Figure 3 an alternative valve 218 is provided which has an exterior control 220, the valve allowing expiratory gases to flow either to the valve 216 or through outlet 226 to atmosphere or a ventilator. Except where otherwise indicated the last two digits of each of the reference numerals used in Figures 3 to 6 correspond with the reference numerals used in Figure 1, indicating like components.

15

In Figure 4 the valve 18 (or 218) is omitted and the pop-off valve 16 (or 216) is replaced by a screw down plunger valve 300 which, in its fully open position allows free passage of gases for controlled ventilation in adults and children and during spontaneous respiration in children. For spontaneous respiration in adults the plunger may

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be screwed down to a desired position to offer a resistance to gas flow. The expiratory gases are scavenged from the outlet 330 or from a ventilator.

Figure 5 is a reversal of Figure 4, the expiratory tube 414 now 5 being the inner of the co-axial tubes. The screw-down plunger valve 400 acting in the same manner as in Figure 4.

Figure 6 is likewise in reversal of Figure 3, the expiratory tube 514 being the outer of the co-axial tubes.

It will be appreciated that the inspiratory and expiratory tubes 10 may lie in configurations other than those illustrated in the drawings.
Furthermore, ~~a~~ soda lime cannisters may be incorporated with ^{/the} two one-way valves and flexible tubing inserted between the expiratory outlet 26 in Figure 1 (or 226, 330, 430 or 526) and port 28 (or 228, 328, 428 or 528). The flow of gases through the one-way 15 valves will be towards port 28 (or 228, 328, 428 or 528). A T-piece connector may be used to connect the reservoir bag 22 (or 222, 322, 422 or 522) and the cannister, valves and tubing with port 28 (or 228, 328, 428 or 528).

1.

An anaesthetic system including a fresh gas supply tube, a reservoir bag connected to the fresh gas supply tube through two outlets, one or both outlets being a valve, and an expiratory tube having one or ~~both of an outlet~~ controlled by adjustable means.

2.

An anaesthetic system according to claim 1 in which there are two outlets to the expiratory tube, a first outlet being controlled by a plug valve and a second outlet ^{/downstream} ~~/upstream~~ of the first outlet being controlled by a relief valve.

3.

An anaesthetic system according to claim 2 in which the relief valve is adjustable or is a pop-off valve.

4.

An anaesthetic system according to any of claims 1 to 3 in which the reservoir bag is connected to the fresh gas supply tube through a plug valve.

5.

An anaesthetic system according to claim 1 in which the expiratory tube is provided with a single outlet controlled by a screw-down type valve.

6.

An anaesthetic system according to any of the above claims in which the outlet of the expiratory tube is located at a position remote from the patient end.

7.

An anaesthetic system substantially as described with
reference to any one of figures 1 to 6 of the accompanying
drawings.



